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Atomic force microscopy of fullerene-indopane monolayers

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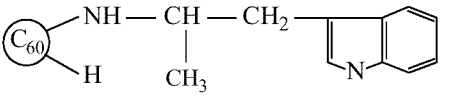
Introduction

The atomic force microscopy (AFM) is a power tool for various surface objects imaging and characterisation in nanometer scale [1] including surface heterogeneity imaging [2]. The resolution up to several nanometers in the scanned plane can be realised with a sharp enough probing tip while the relief height resolution may be as high as several Angstroms. AFM also enables to make manipulations of nanometer scale with the surface objects. In [3] we reported on the results of the tunnelling electron microscopy study of C_{60} fullerene monolayer structure formed by Schaefer horizontal lifting from the fullerene-surfactant mixture. In this paper we report on the results of AFM investigations of C_{60} fullerene-indopane monolayers.

Experimental

The fullerene-indopane layers



were deposited on a highly oriented pyrolytic graphite (HOPG) wafer by Schaefer horizontal lifting [4] from a water without any surfactant. For the comparison the samples were prepared by the horizontal lifting from the pure fullerene layer on the water surface. Silicon cantilevers with about 10 nm tip radius for AFM measurements were used. The tapping mode of operation was exploited. To measure the height of a layer we applied contact AFM mode and used the tip as a micromanipulator for deleting the adsorbed fullerene molecules from the part of the scanned area. Then we again scanned that fragment of the layer using the tapping mode of operation.

Results

Figure 1 represents the relief of a sample with deposited fullerene-indopane monolayer. It shows that the continuous layer is formed. The phase contrast signal is almost constant over the same fragment which confirms the homogeneity of the scanned area. The fragment with the deleted strip of the layer is shown in Fig. 2. The width of the strip is about 80 nm. That enables to estimate the mean thickness of the layer as about 2 nm which corresponds to several fullerene-indopane monolayers. The thickness of the layer is not quite uniform, the scale of the observed knobs is about 10–20 nm in plane and of 0.5–2.0 nm in height.

Figures 3 and 4 show the AFM tapping mode images of a HOPG wafer surface after lifting from the pure fullerene layer on a water surface.

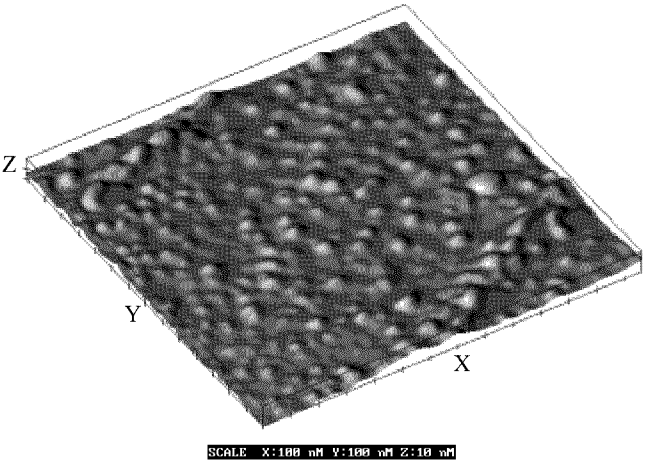


Fig 1. AFM relief image of fullerene-indopane monolayer on HOPG.

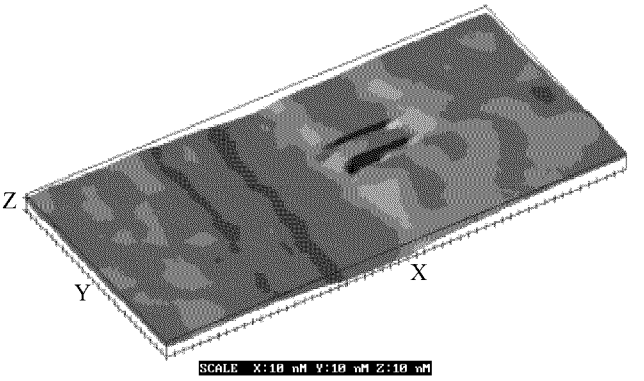


Fig 2. AFM relief image of fullerene-indopane monolayer on HOPG with the deleted strip of the film.

One can see fullerene clusters with the size of about 100–200 nm in plane and of 20–30 nm height both in the surface relief image of Fig. 3 and the phase contrast picture of Fig. 4. The phase contrast image indicates that the interaction between the tip and the surface atoms over clusters differs from that over the free area and thus confirm that they are of different substance.

Conclusion

We have shown that the AFM enables imaging and characterization of fullerene monolayered surface structure. Micromanipulation in nanometer scale in the AFM contact mode is realised. The tapping mode of AFM operation and phase contrast technique proves very effective for layered surface structures study. The AFM investigation reveals a continuous fullerene-indopane film with a thickness of several molecular diameters.

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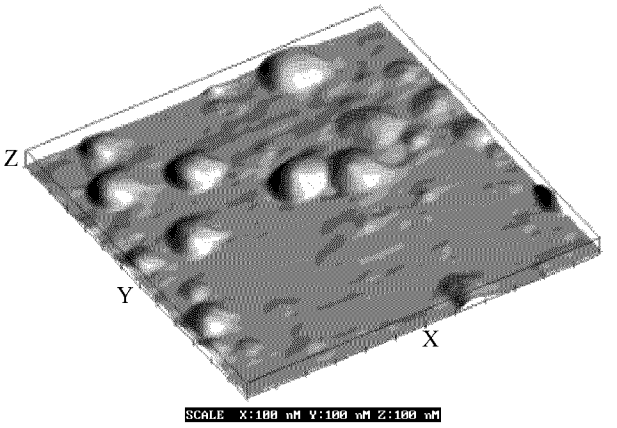

Fig 3. AFM relief image of C_{60} clusters on HOPG.

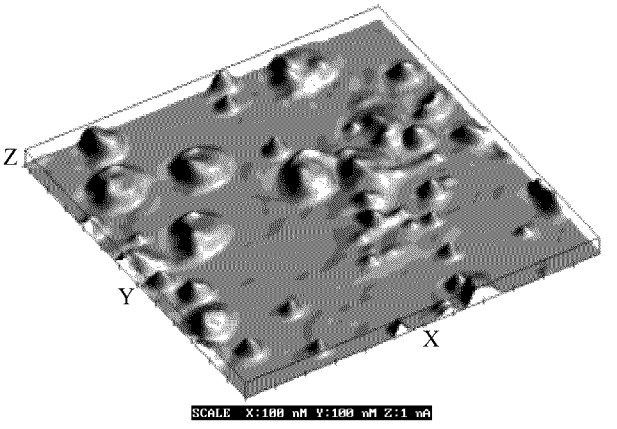

Fig 4. Phase contrast image of the same area.

References

[1] S. M. Cohen, M. T. Bray, and M. L. Lightbody, eds., *Atomic force microscopy/scanning tunnelling microscopy*. U.S. Army Natick Research, Development, and Engineering Center, MA (1994).
[2] Q. Zhong, D. Innis, K. Kjoller, V. B. Elings, *Surf. Sci. Lett.* **290** L688 (1993).
[3] V. A. Fedirko, V. A. Bykov, M. D. Eremtchenko, *Fresenius J. Anal. Chem.* **355** 707 (1996).
[4] I. Langmuir and V. Schaefer, *J. Amer. Soc.* **60** 135 (1938).